Claims

[c1] 1. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal by means of electrodes formed on said electro-optic material to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time; and

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field.

[c2]

2. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output,

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time; and

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field and wherein said third voltage is used to control the intensity of said light source.

[c3] 3. The opto-electric device for measuring the root mean square value of an alternating current voltage according to claim 2 wherein said electro-optic material is an anisotropic lithium niobate crystal.

[c4] 4. The opto-electric device for measuring the root mean square value of an alternating current voltage according to claim 3 wherein a Mach-Zehnder interferometer is formed in said lithium niobate crystal.

[c5]

5. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time;

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field;

e) an environmental container for said electro-optic material; and

f) a temperature control unit for maintaining a set temperature within said environmental container.

[c6] 6. The opto-electric device for measuring the root mean square value of an alternating current voltage according to claim 5 with said environmental container having therein a temperature sensor.

[c7] 7. The opto-electric device for measuring the root mean square value of an alternating current voltage according to claim 5 with said environmental container having therein a heating device.

[c8]

8. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a

period of time;

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field; and

e) a biasing voltage applied to said electro-optic material for setting said electro-optic material to provide essentially zero modulated output.

[c9] 9. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time;

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field; and

e) an ac calibration source with analog to digital conversion for applying a known ac voltage at a known frequency to said electro-optic material.

[c10] 10. An opto-electric device for measuring the root mean square value of an

alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time;

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field; and

e) a voltage correction table for correcting said output voltage.

[c11]

11. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material:

(a) receiving light from said light source;

(b) modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light

from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time;

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root mean square voltage of said applied electric field; and

e) a frequency correction table for correcting said voltage output.

[c12] 12. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an integrated electro-optic material:

(a) receiving light from said light source;

(b) processing and modulating said light; and

(c) providing a modulated light output;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical detector receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time; and

d) a circuit for providing an output voltage that is the root mean square voltage of said applied electric field.

[c13] 13. An opto-electric device for measuring the root mean square value of an alternating current voltage comprising:

a) an electric field-to-light-to-voltage converter comprising:

1) a light source;

2) an electro-optic material having formed therein a Mach-Zehnder-type interferometer, said interferometer comprising:

(a) an input waveguide for receiving light from said light source;

(b) a first waveguide leg and a second waveguide leg divided from said input waveguide for modulating said light; and

(c) and output waveguide combining said first waveguide leg and said second waveguide leg to provide a modulated light output; and

(d) said interferometer operating as a squarer device;

3) an electric field applied to said electro-optic crystal to modulate said light from said light source to produce said modulated light output;

b) an optical receiver for receiving and converting said modulated output light from said electro-optic material to a first voltage that is proportional to a square of said electric field applied to said electro-optic material;

c) an averager circuit receiving said first voltage and providing a second voltage that is proportional to the average of said square of said electric field over a period of time; and

d) an inverse ratiometric circuit receiving said second voltage from said averager circuit and returning a third voltage that is an inverse voltage of said second voltage to said electric field-to-light-to-voltage converter to produce an output voltage that is the root-mean-square voltage of said applied electric field.

[c14] 14. The opto-electric device for measuring the root-mean-square value of an alternating current voltage according to claim 13 wherein said interferometer is made to operate as a squarer device by making said first waveguide leg longer than said second waveguide leg.

[c15] 15. The opto-electric device for measuring the root-mean-square value of an alternating current voltage according to claim 13 wherein said interferometer is made to operate as a squarer device by providing a biasing voltage to said interferometer.

[c16]

16. A Mach-Zehnder interferometer comprising:

(a) an input waveguide for receiving light from a light source;

(b) a first waveguide leg and a second waveguide leg divided from said input waveguide for modulating said light; and

(c) an output waveguide combining said first waveguide leg and said second waveguide leg to provide a modulated light output; and

(d) said input waveguide, said first and second waveguide legs, and said output waveguide operating as a square law device.

[c17] 17. The Mach-Zehnder interferometer of claim 16 wherein said square law device operation is achieved by making said first waveguide leg long than said second waveguide leg.

[c18] 18. The Mach-Zehnder interferometer of claim 16 wherein said square law device operation is achieved by applying a biasing potential to at least one of said first and said second waveguide legs.

[c19] 19. A method for operating a Mach-Zehnder interferometer as a square law device comprising:

(a) providing an input waveguide for receiving light from a light source;

(b) providing a first waveguide leg and a second waveguide leg divided from said input waveguide for modulating said light;

(c) providing an output waveguide combining said first waveguide leg and said second waveguide leg to provide a modulated light output; and

(d) making said first waveguide leg of a length that is longer than said second waveguide leg such that an interferometer formed by said input waveguide, said first and said second waveguide legs, and said output waveguide operates as a non-linear optimum or minimum point.

[c20] 20. The method for operating a Mach-Zehnder interferometer as a square law device according to claim 19 wherein said interferometer operates at a minimum point.